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DISC TYPE ROTARY PLATING DEVICE
[Enbanjo kaitenshiki mekki sochi]

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Specification /435*

1. Name of this Invention

Disc Type Rotary Plating Device

2. Claim(s)

Disc type rotary plating device equipped with an electrolytic tank consisting of plural anodes and single disc type rotary common cathode, wherein each anode is connected to the single disc type rotary common cathode through respective power source so as to control the DC voltage impressed between respective anode and cathode.

3. Detailed Explanation of this Invention

[Industrial Field]

This invention pertains to an improvement of disc type rotary plating device used for manufacturing disk record matrixes or the like.

[Conventional Technology and Its Problems]

With the conventional disc type rotary plating, a disc type plating material is used as a cathode, while anodes are provided at locations corresponding to the plating areas. Then, the necessary metal is usually deposited to a disc type plating object by impressing a voltage between the anodes and cathode while the cathode is rotated. In this case, excluding the case when the anode

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corresponding to a disc type rotary cathode is insoluble and prepared as special shape so as to provide an equal current density at each part of the disc type rotary cathode, when a regular disc type rotary plating process is performed, the current densities at various areas of disc type plating object become different. As a result, these parts of the disc type plating object cannot have the same amount of deposited material, and also, inner stress of the deposited material at each part becomes different. Particularly, this phenomenon is noticeable with a high speed disc type rotary plating when the negative and positive electrodes are placed closely with each other, and a large current is transmitted per unit area.

Therefore, when performing rotary plating, in order to obtain uniform deposit quantity and inner stress at each part of disc type plating material, masking is applied to the cathode and/or anode, or an auxiliary cathode is used. However, in either case, an increased distance is needed between the cathode and anode, which is the counter measure for the high speed rotary plating requiring both electrodes to be drawn closer to each other. Moreover, these methods cause various other problems, such as increased power consumption, larger facility, greater risk of electric shock to the workers due to increased impression voltage, etc. Therefore, generally, these methods are not practically utilized.

On the other hand, when the anode corresponding to a disc type rotary cathode is shaped into a special figure so as to provide equal current density to each part of the disc type rotary cathode, and the anode is insoluble, the deposit amount and inner stress of the deposit material can be uniformly made at each part of the disc type plating material. However, since the anode is insoluble, metallic salt must be used for supplying the metallic ion into an electrolytic solution. Moreover, since the organic additive in the electrolytic solution receives anode oxidation, the usable compositions for the electrolytic solution are limited. Therefore, generally, this method is not utilized practically. /436

Hereafter, the conventional disc type rotary plating device currently commonly used for producing disk record matrixes is explained based on figures.

To manufacture disk record matrixes, using a disk recorder (cutting machine), audio signals are recorded onto a matrix prepared by coating a resin over an aluminum disc, thereby preparing an original disk 1 on which audio signals are recorded. Then, using an applicable method (e.g., electroless plating, vacuum deposition, spattering, etc.), a 300 – 3000 Ǻ thick metal layer (e.g., nickel, silver, copper, etc.) is coated over the prepared original disk 1 containing recorded audio signals so as to form a conductive film 2. Next, a 0.2 – 0.8 mm thick nickel plating (electro-plating) is provided to the original disk 1 containing audio signals and

conductive coat film 2. Then, as shown in Fig. 2, the original disk 1 recorded with audio signals is peeled from the conductive film 2. Thereby, a nickel original disk containing a 0.2 – 0.8 mm thick nickel plating on the conductive film 2 is obtained as a metallic master 3. Using this metallic master 3, a disk record can be produced by resin molding. However, normally, as shown in Fig. 3, passive state processing is provided to the surface of the film 2 of the metallic master 3 by an appropriate method [e.g., soaking into a bichromate salt solution or organic substance (e.g., albumin) solution, or oxidized film creation by anode electrolysis striking]. Then, using nickel plating, a 0.2 – 0.8 mm thick nickel layer (metallic piece 4) is deposited over the film 2′ processed with passive state processing. Thus, as shown in Fig. 4, the coated film 2′ of the metallic master 3 is peeled from the metallic piece 4 to obtain a metallic piece 4. Furthermore, as shown in Fig. 5, the same passive state processing described above is provided to the surface of the metallic piece 4. Then, after a 0.2 – 0.3 mm thick nickel 5 is plated on the processed surface 4′, the layer is peeled from the metallic piece 4 as shown in Fig. 6 to obtain nickel stamper 5.

As descried above, for producing a disk record matrix, nickel plating (electro-plating) is the main step of the production process. Fig. 7 shows the conventional disc type rotary plating device.

This disc type rotary plating device comprises an electrolytic tank 10, DC power source 11, anode 12, disc type rotary cathode 13,

partition wall 14, electrolytic solution inlet 15, and electrolytic solution outlet 16. The electrolytic tank 10 is formed by providing a rubber lining 17 to the inner surface of a stainless steel vessel. The disc type rotary cathode 13 is connected to an anode 12 by a current supply brush 18 through a DC power source 11 and rotated by a motor 19. The bolt 20 at the rotary shaft of the disc center supports the original disk containing audio signals 1, metallic master 3, and metallic piece 4 with a nut 21. The disc type rotary cathode 13 is fitted in a cathode chamber 23 formed by a synthetic resin partition wall 14 having a cloth partition film 22 at the bottom center. Also, the anode 12 is fitted in an anode chamber formed by the electrolytic tank 10 and synthetic resin partition wall 14. The electrolytic solution enters into the cathode chamber 23 through the electrolytic solution inlet 15, overflows, and then enters into the anode chamber 24. Although the electrolytic solution surface of the anode chamber 24 is lower than the electrolytic solution surface in the cathode chamber 23, there is no space between the anode chamber and cathode chamber. Therefore, an electric current can be transmitted through the anode 12 in the electrolytic tank and disc type rotary cathode 13 via the electrolytic solution. A titanium container 26 filled with pellet-like nickel 25 is provided to the anode 12.

Item 27 is a pump for circulating the electrolytic solution. Item 28 is an electrolytic solution reservoir tank. Item 29 is a

ring pressing the periphery of the matrix mounted to the cathode 13. Item 30 is a motor supporting metallic tool. Item 31 is an upper lid. Item 32 is a coupling connecting the rotary shaft of the motor 19 and rotary shaft 33 of the cathode 13. Item 34 is an insulation layer. Item 35 is a spring for letting the insulation material 36 support the current supply brush 18 contacting the rotary shaft 33. Item 37 is an anode support base.

The electrolytic solution consists of sulfamic acid nickel, boric acid, small amount of surfactant (Antibit agent), nickel /437 chloride, etc. An example composition is the following:

Sulfamic acid nickel	360 g/l
Boric acid	30 g/l
Nickel chloride	6 g/l
Surfactant	2 cc/l

The following explains the method of producing a nickel stamper 5 using a metallic piece 4, as a practical example of nickel plating (electro-plating) for producing disk record matrix.

Prior to nickel plating, the pH of the electrolytic solution of the abovementioned composition is adjusted to 4.2 ± 0.1 with acid or alkali, and the liquid temperature is adjusted to 53°C ± 2°C. Using a circulation pump 27, the electrolytic solution is supplied to the cathode chamber 23 through the electrolytic solution inlet 15. The electrolytic solution overflowed from the cathode chamber enters into the anode chamber 24. An excessive electrolytic solution in the anode chamber enters into the reservoir tank 28 and then returns to

the circulation pump 27. Thus, nickel plating preparation is completed.

The metallic piece 4 is cleaned, soaked in bichromate potassium solution to provide passive state processing, and sufficiently washed with water. Then, the center hole of the metallic piece 4 is inserted into the bolt 20 at the center of the rotary shaft of the disc type rotary cathode 13 of the disc type rotary plating device, fixed with a nut 21, and further strongly fixed with a periphery-pressing ring 29. Next, after the motor 19 is activated to rotate the disc type rotary cathode 13, voltage is immediately impressed using the DC power source 11 to transmit a current. This current is 30 A for the first 5 minutes from the time of initial current transmission for the matrix having the diameter of 350 mm. Then, 140 A current is transmitted. Thus, nickel plating completes at the total current of 140 amperes. The metallic piece 4 is released form the disc type rotary cathode 13, and the disc prepared by depositing the nickel stamper 5 on the metallic matrix is removed, washed with water, and dried. Then, the metallic piece 4 and nickel stamper 5 are separated to obtain the nickel stamper 5. The thickness gap of the concentric circle of the nickel stamper 5 is unrecognizable in micrometer. On the other hand, each part in the diameter direction formed large gaps.

The thickness at each location having different distance from the center of the nickel stamper obtained as described above was

measured. The results are shown in Table 1. Note that every sample was 152 g.

Table 1

（単位：mm）

測定位置（中心部からの距離 mm）	20	50	80	110	140	160
試料 A－1	0.170	0.175	0.175	0.180	0.200	0.235
A－2	0.180	0.175	0.175	0.185	0.190	0.220
A－3	0.170	0.170	0.180	0.180	0.205	0.230
A－4	0.175	0.175	0.180	0.185	0.195	0.220
A－5	0.165	0.165	0.175	0.180	0.205	0.235

Key:

(Unit:mm)

Measurement loc (distance from						
Sample A-1 A-2						

In Table 1, the thickness of the peripheral area is 20 – 40% /438
greater than that of the center area. This is because, electric current is concentrated on the peripheral area. That is, the current distribution is not uniformly made. Generally, if the electrolytic solution composition and electrolytic condition (excluding the current density) are fixed, the inner stress of the deposited substance is known to have a fixed value at each current density. Therefore, uneven current distribution simply indicates uneven inner

stress of the deposited substance. Hence, the nickel stamper 5 forms a curled peripheral area due to tensile stress (see Fig. 8).

On the other hand, disk records were produced in the sequence of an original disk containing recorded audio signals 1, metallic master 3, metallic piece 4, and nickel stamper 5. Then, a resin mold was used to produce a disk. That is, normally, 3 times of nickel plating process were performed. During this process, the flatness of nickel stamper 6 was lost due to the influence of inner stress in the deposited substance, subsequently causing the flatness loss of the disk record. Although the appearance of disk record is flat, actually it had various undulations to cause troubles in signal generation. Generally, the inner stress of nickel plate deposit substance can be improved by adding an additive to an electrolytic liquid. Examples of additive reducing the inner stress are saccharine, sulfonic, amide, benzene, sulfonic amide para toluene, 1,3,6-naphtharene sulfonic acid, etc. However, it is known that each additive used to reduce the inner stress described above does not make the inner stress equal at each current density. Therefore, in order to obtain uniform inner stress which is close to zero, first, the current distribution must be made uniform. That is, the current density must be equalized at each area with an appropriate amount of stress reducing agent. However, since the density of current transmitted through the cast matrix surface significantly changes according to the matrix shape and anode shape, it is considered

impossible to process at uniform current density. Even if the current density for providing zero inner stress in the deposit was available, the electroplating could not be performed uniformly utilizing such the current density.

According to one theory, by arranging the distance between the anode and cathode as a length at least 5 times greater than the diameter of the disc, the current density can be made uniform. However, this method is economically difficult. Also, although some methods, such as forming a shield plate at the anode or cathode as a mask, reducing the excessive current by providing an auxiliary electrode, etc., were tried, they could not control the current quantitatively, thereby failing to provide expected results.

[Purpose of this Invention]

This invention solves the problems described above. Particularly, in the case of high speed disc type rotary plating by setting an anode and cathode close to each other and transmitting a large current per unit area, the device based on this invention controls the current density at each area of the disc type rotary cathode so as to provide uniform inner stress of the deposited substance at each part of the disc type plated material and produces a required amount of deposited material at each area of the plated material.

[Constitution of this Invention]

Disc type rotary plating device equipped with an electrolytic tank consisting of plural anodes and single disc type rotary common cathode, wherein each anode is connected to the single disc type rotary common cathode through respective power source so as to control the DC voltage impressed between respective anode and cathode. Thus, the deposit quantity and inner stress of the deposit at each area corresponding to the plural anodes provided for a single disc type rotary common electrode can be controlled.

[Operational Examples]

Hereafter, this invention is applied to a disc type rotary plating device used for producing a disk record matrix based on the figures.

Note that this invention is not limited to the production of disk record matrix, as it can be applied to the matrix for compact disk, video disk, data disk, etc., and therefore, application of this invention is not particularly restricted to a certain device.

Fig. 9 is a diagram of disc type rotary plating device based on this invention. The cathode side of this disc type rotary plating device is identical to that of the conventional example. Items 38, 39, and 40 are respectively independent DC power sources. Items 41, 42, and 43 are anodes shaped as three-layered rings as shown in Fig. 10. The anode is isolated by the annular isolation plates 44, 45 made of an electrically insulating material.

The disc type rotary common cathode 13 rotatably by the motor /439
19 is electrically connected to respective three-parts anode electrodes 46, 47, and 48 of the anodes 41, 42, and 43 through the shaft 33, current supply brush 18, and three independent DC power source 38, 39, and 40. This disc type rotary common cathode 13 is set to the cathode chamber consisting of a synthetic resin partition wall 14 having a circular cloth partition film 22 at the center of the bottom. Also, cathodes 41, 42, 43 consisting of three parts are set on the anode support base 37 of the anode chamber 24 formed by the electrolytic tank 10 and partition wall 14. The electrolytic solution entered into the cathode chamber 23 through the electrolytic solution inlet 15, overflows, and entered into the anode chamber 24. The electrolytic solution surface of the anode chamber 24 was lower than the electrolytic solution surface of the cathode chamber 23. However, no space was formed between both chambers 23, 24. Thus, each of three cathodes 41, 42, 43 in the electrolytic tank and disc type rotary common cathode 13 could be electrically connected through the electrolytic liquid. Each of three anodes 41, 42, 43 were respectively prepared by filling pellet-like nickel 50 in a three-layer annular titanium case 49. The electrolytic solution consisted of sulfamic acid nickel, boric acid, small amount of surfactant (Antibit agent), nickel chloride, etc. Example compositions are the following:

Example 1:

Sulfamic acid nickel	350 g/l
Boric acid	30 g/l
Nickel chloride	6 g/l
Surfactant	2 cc/l

Example 2:

Sulfamic acid nickel	350 g/l
Boric acid	30 g/l
Cobalt chloride	30 g/l
Surfactant	2 cc/l

The following explains the method of preparing a nickel stamper 5 using a metallic piece 4 as a practical example of nickel plating (electro-plating) for producing disk record matrix when the electrolytic solution compositions 1 and 2 were used.

Prior to nickel plating, the pH of the electrolytic solution of the abovementioned composition was adjusted to 4.2 ± 0.1 with acid or alkali, and the liquid temperature was adjusted to 53°C ± 2°C. Using a circulation pump 27, the electrolytic solution was supplied to the cathode chamber 23 through the electrolytic solution inlet 15. The electrolytic solution overflowed from the cathode chamber entered into the anode chamber 24. The excessive electrolytic solution in the anode chamber entered into the reservoir tank 28 and then returned to the circulation pump 27. Thus, nickel plating preparation was completed.

The metallic piece 4 was cleaned, soaked in bichromate potassium solution to provide passive state processing, and sufficiently washed

with water. Then, the center hole of the metallic piece 4 was inserted into the bolt 20 at the center of the rotary shaft of the disc type rotary cathode 13 of the disc type rotary plating device, fixed with a nut 21, and further strongly fixed with a periphery-pressing ring 29. Next, after the motor 19 was activated to rotate the disc type rotary cathode 13, voltage was immediately impressed using the DC power sources 38, 39, 40 to transmit a current. This current was 30 A for the first 5 minutes after the initial current transmission in the case of matrix having the diameter of 350 mm. The ratios of respective power sources were 38 : 39 : 40 = 0.8 : 1 : 1.1. Then, 5 minutes later, the total current was increased to 140 A. The ratios of respective power sources were 38 : 39 : 40 = 0.7 : 1 : 1.1. Thus, nickel plating completed at the total current of 140 A. The metallic piece 4 was released form the disc type rotary cathode 13, and the disc prepared by depositing the nickel stamper 5 on the metallic matrix was removed, washed with water, and dried. Then, the metallic piece 4 and nickel stamper 5 were separated to obtain the nickel stamper 5. The thickness gap of the concentric circle of the nickel stamper 5 was unrecognizable in micrometer. On the other hand, the thickness at each measurement point in the diameter direction was ±3% of the standard thickness. The thickness of each measured point is shown in Table 2. In the table, samples B-1 – B-5 are the results of electrolytic solution consisting of

composition example 1, and samples B-6 – B-10 are the results of composition 2. Every weight of each sample was 152 g.

/440

Table 2

第 2 表

（単位：mm）

測定位置（中心部からの距離，mm）	20	50	80	110	140	160
試料 B－1	0.185	0.185	0.180	0.180	0.180	0.175
B－2	0.185	0.185	0.185	0.180	0.180	0.175
B－3	0.185	0.185	0.180	0.180	0.175	0.175
B－4	0.185	0.180	0.180	0.180	0.180	0.175
B－5	0.180	0.180	0.180	0.180	0.180	0.175
B－6	0.185	0.185	0.180	0.180	0.175	0.175
B－7	0.185	0.185	0.185	0.180	0.175	0.175
B－8	0.185	0.185	0.180	0.175	0.175	0.175
B－9	0.185	0.180	0.180	0.180	0.180	0.175
B－10	0.180	0.180	0.180	0.180	0.180	0.175

Key:

(Unit: mm)

Measurement location (distance from the center)						
Sample B-1 B-2						

[Effect of this Invention]

As described above, the plating device of this invention uses an electrolytic tank consisting of plural anodes and single disc type rotary common cathode, connecting plural anodes to a single disc type rotary common cathode through respective power sources. Therefore, a DC current is impressed between respective cathode electrode and anode electrode to control the current impression individually so as

to manage the electric current densities provided to the disc type rotary common electrode respectively connected to the anode parts. Thus, cathode current densities can be uniformly controlled easily, thereby allowing easy control over the deposit quantity and inner stress of the deposit substance at each part of the disc type plated material. Moreover, the electrolytic solution consisting of the composition 2 contained 30 g/l of cobalt chloride, thereby forming a nickel and cobalt alloy deposit, where the cobalt content in the deposit was 27 wt%, and the Vickers hardness was R 470. On the other hand, in the case of the deposit of the composition example 1 (i.e., electrolytic solution not containing cobalt), both Vickers hardness of the disc type rotary plating methods of the conventional and this invention did not exceed HV 200. Thus, the nickel and cobalt alloy deposit had strong hardness, and therefore, was one of materials close to the ideal mold matrix to which friction resistance was required. This type of nickel-cobalt alloy plating is sensitive to the change of cathode current density, providing rapid stress variation with slight cathode current density change. Therefore, when uniform cathode current densities could not be provided, the plating could not be applied to the electroplating. However, as the method of this invention can easily provide uniform cathode current densities, the cobalt-nickel alloy deposit as shown in Table 2 can be produced. The capacity of forming uniform cathode current densities also makes it possible to improve other type of deposits (e.g.,

nickel deposit provided by adding an organic compound to the electrolytic liquid).

4. Simple Explanation of the Figures

Figs. 1 – 6 are diagrams showing the processes of producing a nickel stamper from an original disk to which audio signals are recorded. Fig. 7 is a cross-sectional diagram of a typical conventional disc type rotary plating device. Fig. 8 is a cross-sectional diagram showing the nickel stamper having the curled periphery area. Fig. 9 is a cross-sectional diagram of disc type rotary plating device used in the operational example of this invention. Fig. 10 is a diagram showing the area X-X’ of the device shown in Fig. 9. Fig. 11 is a cross-sectional face of the titanium anode of the same device. Fig. 2 is the cross-sectional side face of the same device.

10...Electrolytic tank; 13...Disc type rotary cathode; 38 – 40...Power source; 41 – 43...Anode; 49...Vessel; 50...Pellet-like nickel

Figure 1

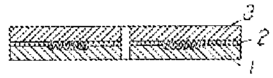

Figure 4

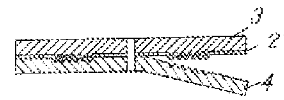

Figure 2

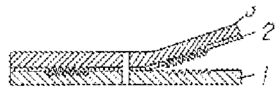

Figure 5

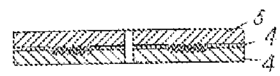

Figure 3

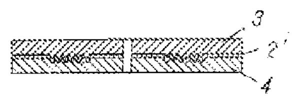

Figure 6

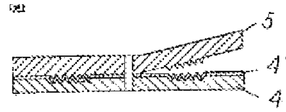

Figure 7

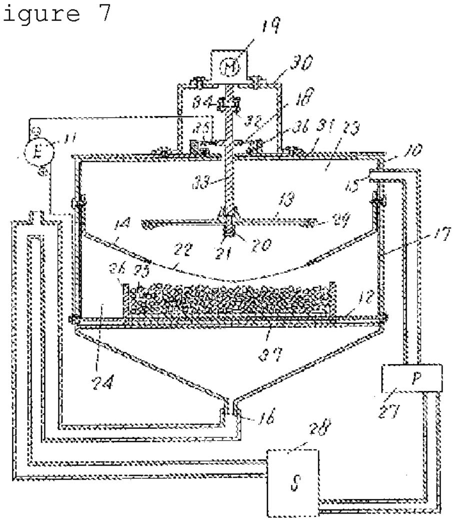

Figure 9

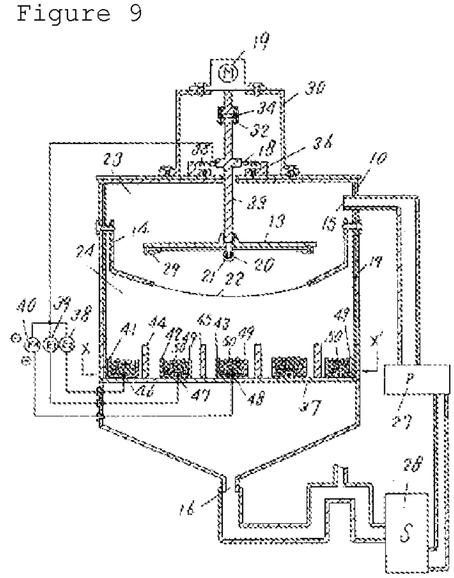

Figure 8

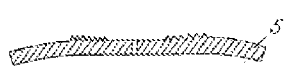

Figure 10

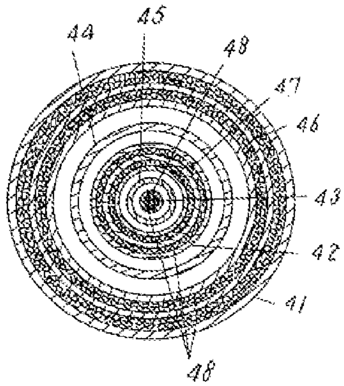

Figure 11

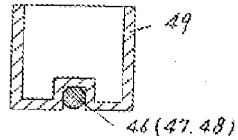

Figure 12